An Investigation on Occupational Noise Exposure in Kerman Metropolitan Bus Drivers

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ABSTRACT

Noise is one of the major hazardous occupational exposures and one of the occupations at risk is the transportation industry. However, few studies have measured and reported the amount of noise exposure in drivers. In this study, we evaluated noise exposure among the public transportation bus drivers of one major Iranian city, Kerman, southeast Iran. Eighty public transportation buses in the streets of Kerman, Iran in 2010 were randomly sampled during weekdays business hours and in each driver noise exposure was measured for 10 minutes according to the standard methods. The noise exposure was measured in 4 different models of buses. All of the buses were 7 or fewer years old. There was no significant difference in the noise produced by the 4 models. The measurements were similar ranging from 65.9 dBA to 79 dBA. The noise pressure, measured in a range from 31.5 Hz to 8000 Hz, decreased from about 90 dBA to 50 dBA as frequency increased but was below 85 dBA in the speech frequencies. The noise levels measured in these buses for the drivers were under the 85 dBA threshold for speech frequencies, and by sure less than 85 dBA for the passengers; it will probably not cause hearing or other health related problems. However, more studies in this field are suggested.

Keywords: Noise Exposure, Bus Drivers, Iran

INTRODUCTION

Noise is one of the most important occupational risk factors both in industry and transportation [1]. Many of the industries are associated with noise, such as steel industry, automobile industry, dyeing industry, agriculture, electronics, pharmaceutics, military, construction work, cement factories and transportation [2]. Exposure to continuous noise above the 85 dBA may lead to hearing loss. This loss is different from person to person and depends on the frequency of the noise and the duration of exposure [3].

The health status of bus drivers as a stress prone job has been studied by different groups including epidemiologists, sociologists, physicians, psychiatrists and engineers [4]. Bus drivers are exposed to different hazardous factors such as loud noise, rise and fall in temperature (due to opening and closing the door and working in different seasons outdoors), vibration, ergonomic factors and safety hazards such as collisions and accidents [5]. Drivers can be exposed to high noise
levels in their shifts by working on old and faulty machinery, bumpy roads and transportation of masses of people. The noise exposure level in a bus depends on factors such as the motor noise in high speeds, the traffic sound, the bus route and the number of people transported. The noise is majorly created by the engine, gear, pedal, accelerator and the breaks. This noise can not only disturb the driver but can also disturb the other surrounding people [6]. High noise levels can causes high blood pressure, high pulse rates, enhanced muscle reflexes and sleep disturbances [7]. The effect of high noise levels on hearing depends on factors such as noise levels, exposure time, noise frequency, individual sensitivity, environmental factors and physiological factors. The frequencies between 500 kHz to 4000 kHz are important for understanding human speech and high noise levels in these frequencies interrupt speech [8].

Although bus drivers have an important role in public transportation, decreasing the traffic load and decreasing air pollution in big cities, only a few studies have studied noise exposure in bus drivers. In this study we measured levels of noise exposure among bus drivers in one major Iranian city, Kerman, southeast Iran.

MATERIAL AND METHODS

This cross-sectional study was designed to measure noise exposure levels in Kerman City public transportation bus drivers in 2010. From more than 240 buses working in the city public transport system of Kerman City and its suburbs, 80 buses including twenty 0355 Benz buses, twenty 0457 Benz buses, twenty Renault buses and twenty Megatrans buses were chosen randomly and in different commuting routes. The 0355 Benzes make 58% of the Kerman public transport buses; their capacity is 30 passengers and their average age is about 7 years. The 0457 Benz buses constitute 12% of the city public transport buses; their capacity is 30 passengers and their average age was 6.5 years. The Renault buses make 16% of the Kerman public transport buses; their capacity is 30 passengers and they are 4 years old. The Megatrans buses make 14% of the Kerman public transport buses; their capacity is 40 passengers and they are 3.5 years old.

Equal samples were taken from each bus model to estimate the noise exposure in each model. Our calculations showed that with a power of 0.8, type one error of 0.05, precision of 0.1 and standard deviation of 0.11 a sample size of 12 for each model would be enough. In this study we used 20 buses from each model.

The fuel of all buses included in the study was diesel oil and their average speed in the city commuting routes according to a statement from the Kerman city bus drivers’ corporation was an average of 40 km/h.

The buses were approved mechanically and technically for working on the roads. Kerman streets do not have a significant slope and thus the effect of the street slope on their noise production was negligible. Before measuring noise exposure, with the cooperation of the Kerman City bus drivers corporation, the routes of the buses were determined and then randomly somewhere in the buses commuting routes and during the routine day time working hours (from 7 am to 5 pm), on working days and when the buses had commuters on board and the weather was clear and not rainy or windy, the measurements were done. Thus the effect of weather conditions on noise was neglected.

A sound level meter (model CEL450) was used for measuring and the device was calibrated beforehand by a model CEL450 calibrator.

Measurements were not done during holidays, due to the low traffic and low number of buses for sampling in the streets. Drivers were exposed to a relatively steady amount of noise during their work shifts and thus the noise exposure was measured for only 10 min in each bus. The measurements were done based on the ISO 5128:1980 standard for measuring noise inside motor vehicles. The 10 min equivalent Level (Leq 10) was measured in the A-weighted filter network and the fast response was measured and was generalized for eight working hours (Leq, 8h) as the Kerman city bus drivers obey the national working regulations of 40 h a week and 8 h a day working hours.

Most noises contain a mixture of sounds with different frequencies. In order to correctly determine the characteristics of a noise, it is necessary to determine the sound pressure level at each octave band frequency separately. The sound pressure level was measured at the octave band center frequencies of 31.5, 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hz at the ear level of the driver on each bus. The noise was measured when the buses were commuting and in a 10±1 cm distance of the drivers right ear [9]. In Iran driving is done on the right side of the road and the driver sits in the left side of the vehicle. Therefore on the right side there was enough space for the researchers to stand and do the measurements.

In different routes, measurements would start from the time the bus started moving from one station to the next station. Then, the researchers would get off the bus and board another bus. The Speech Interference Level (SIL) is a parameter for determining the effect of the background noise on speech interference and is calculated by averaging the noise levels at 500, 1000, 2000 and 4000 Hz. SIL is calculated according to the equation below [10].

\[
SIL = \frac{SPL_{500} + SPL_{1000} + SPL_{2000} + SPL_{4000}}{4}
\]

In the above equation the SPL is the Sound Pressure Level (dBA) at frequencies 500, 1000, 2000 and 4000 Hz. The speech interference level which permits reliable conversation at the distance between the driver and the passenger (in meters) was estimated according to standard curves and tables [11].

RESULTS

The results of measuring noise exposure levels of the bus drivers in the commuting public transport buses...
Table 1. The results of noise exposure measurement of Kerman Bus Drivers

<table>
<thead>
<tr>
<th>Bus Type</th>
<th>Number</th>
<th>Mean (dB)</th>
<th>Maximum (dB)</th>
<th>Minimum (dB)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0457 Benz</td>
<td>20</td>
<td>74.26</td>
<td>79.0</td>
<td>69.0</td>
<td>2.59</td>
</tr>
<tr>
<td>0355 Benz</td>
<td>20</td>
<td>73.54</td>
<td>76.7</td>
<td>69.2</td>
<td>2.39</td>
</tr>
<tr>
<td>Renault</td>
<td>20</td>
<td>71.97</td>
<td>76.9</td>
<td>65.9</td>
<td>3.60</td>
</tr>
<tr>
<td>Mega Trans</td>
<td>20</td>
<td>71.93</td>
<td>73.6</td>
<td>70.0</td>
<td>1.21</td>
</tr>
</tbody>
</table>

ANOVA p-value > 0.05

Table 2. The Speech Interference Levels (SIL) and the calculated effective distance between the driver and passengers

<table>
<thead>
<tr>
<th>Bus Type</th>
<th>SIL (dB)</th>
<th>The effective distance between the driver and the passenger (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0457 Benz</td>
<td>61.57</td>
<td>0.36</td>
</tr>
<tr>
<td>0355 Benz</td>
<td>61.48</td>
<td>0.47</td>
</tr>
<tr>
<td>Renault</td>
<td>59.51</td>
<td>0.57</td>
</tr>
<tr>
<td>Mega Trans</td>
<td>59.36</td>
<td>0.59</td>
</tr>
</tbody>
</table>

have been summarized in Table 1. The highest amount of noise exposure measured (79 dBA) was in a 0457 Benz bus and the lowest amount measured (65.9 dBA) was in a Renault bus. There was no significant difference in the mean amount of noise exposure measured in the four bus types (p-value of ANOVA test >0.05).

The efficient distance between the driver and the passengers during routine working hours was calculated based on the SIL and according to the above mentioned equation [11]. The SIL and the effective distances between the driver and the passengers during usual working hours are shown in Table 2. As it can be seen the SIL was highest among the 0457 Benz bus drivers (61.57 dBA) and is lowest among the Renault bus drivers (59.36 dBA). Respectively the shortest effective distance was 0.36 meters and the longest was 0.59 meters.

The results of noise frequency analysis for the different bus types during commuting in the routes and beside the drivers’ right ear have been shown in Figure 1. The pressure of the noise measured in a range from 31.5 Hz to 8000 Hz, decreased steadily from about 90 dBA to 50 dBA as frequency increased. Although the noise measured in low frequencies was higher, the pressure was below the 85 dBA threshold in the speech frequencies. We did not find a significant association between the bus age or bus route and the noise level.

DISCUSSION

The objective of this study was to evaluate the exposure levels of Kerman city public transportation bus drivers to noise. According to these results, the
drivers of 0457 Benz buses had the highest mean noise exposure (74.26 dBA) and the drivers of the Megatrans buses had the lowest mean noise exposure (71.93 dBA), which according to the ACGIH standards, is less than the standard 85 dBA threshold exposure.

Noise is one of the dangerous pollutants in big cities. In a study done in Lahore, Pakistan, 65% of the public transport drivers had Grade 1 or slight hearing impairment (hearing loss of 26 – 40 dBA) and 10% of the drivers had Grade 2 or moderate hearing impairment (hearing loss of 41 – 60 dBA). However the researchers did not measure the actual amount of noise exposure in dBA, but mentioned that there is excess noise on the roads in all major cities in Pakistan [12].

Another similar study in India showed that drivers’ noise exposure inside the buses were between 89 to 106 dB. The audiograms of these drivers showed that 89% of them had hearing impairments [17]. Another study on bus drivers in Kalkate, India showed that in 49.6% to 55% of the measurements, drivers’ noise level was 85 dB or higher [6].

The only study done to our knowledge in Iran was in 2009 in Tehran that showed the bus type and the bus age are factors related to the amount of bus drivers' noise exposure. Similar to the current study results, the Tehran study showed that the 8 hour exposure level for the buses was less than 85 dBA [13]. A study done in 2008 in Brazil showed that among the 60 buses evaluated, a number of 56 buses had sound exposure levels equal or less than 82 dBA, but all buses were above 65 dBA (A). The year of manufacture and the location of the engine were two factors that highly contributed to the level of noise received by the driver [14]. Another study done in Brazil in 2010 showed that there was a significant difference among bus models and the emitted noise. Also drivers who worked with rear engine vehicles were significantly exposed to lower noise levels than those who worked in buses with front engine buses. Negative, but not strong correlations were found between year of manufacture of the vehicle and the intensity of the noise, in other words older buses emitted higher noise [15]. The study in Brazil in 2003 showed that all of the bus drivers were exposed to noise above 65 dBA. Also, in this study the year of manufacture and the location of the engine were relevant factors in determining the noise the drivers were exposed to [16]. According to the Brazil national standards (NR-17) a level of exposure that exceeds 65dBA during 8 hours of work is considered uncomfortable [15-16].

In a study done in Brazil in 2005, the average noise exposure in drivers working on buses with the engine in front was 83.6 dBA and in the drivers with the engine in back was 77 dBA, and the level of noise emission above 86.8 dBA (A) was a risk factor for noise induced hearing loss [9].

In our study, the noise exposure levels in all four models were relatively similar with small variations. Buses with the same model had the same age, and thus, we were not able to study the effect of the bus’s age on noise production. In all four bus models, the engine was in the back and far from the driver. Also, the bus speed was relatively similar and steady and about 40 km/hour in inner city routes, which made comparisons for speed impossible. At the time our study, all buses were well maintained and 7 or less years of age. It is possible that older and less maintained buses make more noise, but we were not able to show this in our study.

Almost all human speech is between 200 Hz to 6000 Hz. If the environmental noise is high enough, people will not be able to understand other people's speech, the environmental noise will interfere with speech and this can lead to accidents [10, 12]. As Figure 1 shows, the noise produced in lower frequencies was higher than the noise produced in higher frequencies and about 50 to 60 dBA of noise exposure was in the speech limits and can interfere with speech.

Although the results show that in the worst situation the noise exposure level in Kerman bus drivers was 79 dBA, which is below the 85 dBA threshold and it has been mentioned in studies that noise levels of 70 dBA or less, do not damage hearing [12], other articles have mentioned that a level of exposure exceeding 65 dBA during 8h of work is uncomfortable [15, 16]. Therefore the current values cannot be considered optimal for health and if possible should be reduced in order to improve the work environment of bus drivers subjected to these noise levels [15]. However, we do not have any information on the amount of hearing loss or discomfort in the drivers of Kerman to confirm or deny this.

CONCLUSION

Although the maximum level of noise exposure in Kerman public transport bus drivers was less than the standard 85 dBA threshold, more studies are needed to confirm the safety of these levels for bus drivers in 8 hour shifts.

ACKNOWLEDGEMENT

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REFERENCES


